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Comparative Analysis of Image Enhancement Quality Based on Domains

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Abstract

First method is spatial domain and the effective of four diverse image spatial techniques (histogram equalization, adaptive histogram, histogram matching, and unsharp masking) produce sharpening and smoothening of image. Secondly, frequency domain technique and the effective of three diverse image spatial techniques (bilateral, homo-morphic and trilateral filter) were examined to achieve low noise image. Finally, SVD,QR,SLANT and HADAMARD was examined whichincreased human visual. For the above techniques, different quality parameters are evaluated. From the above evaluation, the proposed method identifies the best method among the three domains.

Keywords: *Digital watermarking, frequency domain, image enhancement, quality measures, spatial domain, transform domain.*

INTRODUCTION

Image enhancement processes consist several technique and its main goal is to improve the visual appearance of an image [24,8]. Applications such as digital photography, medicine, geographic information system, industrial inspection, law enforcement and many more digital image applications requires the image enhancement technique [10]. In general, image enhancement means a process of smothering irregularities and noise reduction in the corrupted image [1]. [21]In the recent years, image enhancement has evolved to denote image-preserving noise smoothing. In digital image processing, enhancement of contrast and sharpness is general problem [1] [8] [10]. To rectifying these remarks, many approaches for enhancement from images have been proposed in this study. Acquired image can be in the form of gray scale or color. [6]RGB color space is not efficient for real world images and intuitive application; there is a need for color transformation so that we can convert RGB to HSV channel and this technique isused in our proposed work [7]. This HSV technique is intuitive and efficient for real world applications. Histogram equalization of Dualistic Sub-Image, minimum mean brightness error [8]and mean preserving bi histogram equalization [2][1], uses entropy value [17] and mean value for histogram separation. These methods reduce the problem of brightness preservation. CLAHE [18](contrast limited adaptive histogram equalization) based FPGA [3]method generates histogram for each pixels in an image and each histogram is theoretically distributed without iterations by feeding back the distribution result of its former pixel. This method generates smooth enhanced images without over-amplifying noises in the image. [4]Histogram Matching (HM) is to find a monotonic mapping between reference and test images using their histograms which give enhanced image. For low contract image the unsharp masking gives noise free output and sharpening image by using the weighted low pass filter. Spatial domain filter kernel provides excellent contrast enhancement and sharper edges using homomorphic filtering [7]. Lin et al. [9], artefacts between adjacent low frequency bands are suppressed by smoothing low frequency bands and discarding invalid high frequency ones are reduced by a simplified bilateral filter. To overcome the drawbacks of fast bilateral filter, we introduce the improved version of bilateral filter is trilateral filter [11][21]. This filter has two noise detectors ROLD and ROAD for discovery of noise present in damaged pixels. Finally, all type of noise applicants are reconstructed by using trilateral filter.

METHODOLOGY

The input image is color which may be in the file format of (jpg, png, bmp, and tiff) and in compressed or uncompressed formats. Then, the image is transformed into a color space. The different color spaces are RGB, HSV, YIQ, LAB and YCbCr. Image enhancement is to increase the quality of images using spatial, frequency and watermark transform domain (Figure 1).

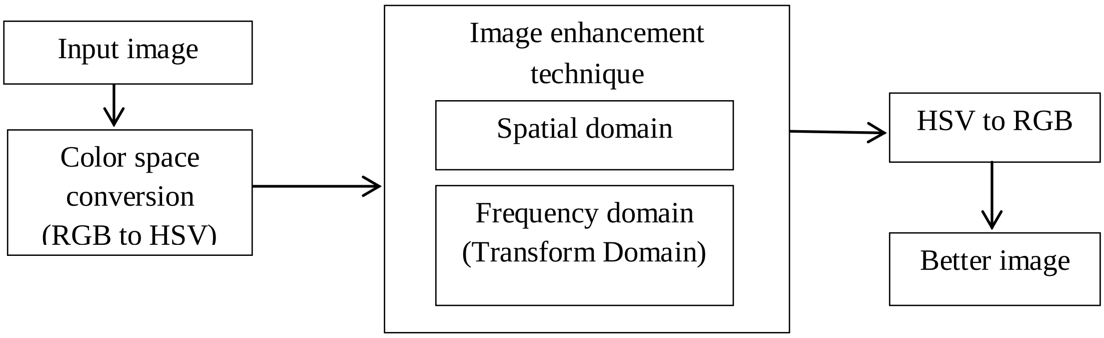

Figure 1: *Architecture of image enhancement.*

RGB color space is transformed to hue, saturation and luminance (HSV) color space which is intuitive and efficient for real world applications. Here, Hue represents dominant wavelength of the color stimulus; Saturation displays the relative color purity. H and S are jointly called the chromaticity coordinates.

Monotonic mapping between a test and reference image of histograms are computed by Histogram Matching. Test and reference images can be any of the permissible data types and need not be equal in size. This matching technique increases the contract based on similarity between test and reference image.

Homomorphic filtering depends on logarithm-based image enhancement process and it use to focus details in an image scene. It achieves this task by providing concurrent dynamic range compression and contrast enhancement. It uses logarithm and frequency domain transforms and exponential operator to recover the dynamic range after processing. In the frequencydomain, Homomorphic filtering technique is mathematically defined as;

$$Z'(x,y)=e^{F^{-1}}\{F\{\ln|z(x,y)|\}*H_{HPF(u,v)}\})$$

Where $Z'(x,y)$is processed image, $H_{HPF}^{(u,v)}$ the frequency domain high pass filter (HPF), while u and v are the frequency coordinates. The symbols F and F^{-1} are the forward and inverse Fourier transform operators respectively.

Trilateral filter is an advanced filtering technology which can preserve edges and remove noise as well. This filter is not only enhancing image contrast and avoids halo but also preserve edges and texture.

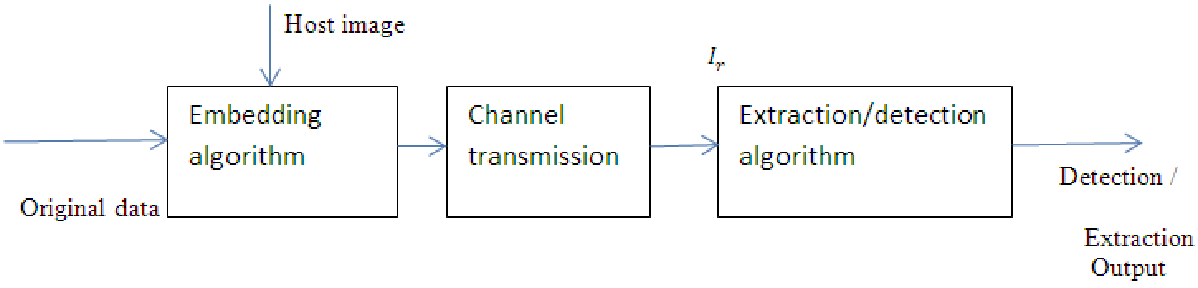

***Figure 2:** Generalblock diagram of watermarking.*

RESULTS AND DISCUSSIONS

Image quality assessment of spatial and frequency domain images

The proposed method is implemented in MATLAB R2016a. The Lena image is taken as an input for this process. Fig. 3 shows that the processed images of proposed image enhancement technique is based on spatial domain.

The spatial domain results relating to the spatial images are presented in Fig. 4.Before enhancing the image from the original image, the input image must be pre-process, this can be done by HSV color space conversion. Visual evaluation of a spatial result can indicate whether an enhancement of spatial method is successful; Qualitative evaluation does not always lead to successful interpretations since there may be some spectral and spatial distortions in the spatial images that cannot be detected by human eye.

***Table 1:** Parameter Analysis for Image quality measure.*

MSE: Mean square error is given by, MSE = $\frac{1}{UV}\sum_{i=1}^{U}\sum_{j=1}^{V}(f(i,j) - f'(i,j))^2$	**PSNR:**Peak square noise ratio is given by, PSNR = $10\log_{10}(\frac{MAXI2}{MSE})$
MAD: Mean Absolute Deviation is given by, MAD = $\frac{\sum_{t=1}^{n}\lvert At-Ft\rvert}{n}$ Where At and Ft are the pixel values of the test and enhanced image, respectively.	**CC:** Correlation coefficient is given by, $C_c = \frac{\sum_{i=1}^{n}(X_i-\bar{X})(Y_i-\bar{Y})}{\sqrt{\sum_{i=1}^{n}(X_i-\bar{X})^2}\sqrt{\sum_{i=1}^{n}(Y_i-\bar{Y})^2}}$ Where xi, yi are the grey values of homologous pixel synthesised image and real high resolution image.
Entropy: Entropy is given by, H= $-\sum_{i=1}^{R} d(i)\ln_2 c(i)$ Where R is the number of color level of the histogram image.	**ERGAS:** Relative dimensionless global error in synthesis given by, (ERGAS) ERGAS= $100\frac{h}{l}\sqrt{\frac{1}{k}\sum_{k=1}^{K}\left(\frac{RMSE(K)}{\mu(K)}\right)^2}$
RASE: RASE is given by, RASE = $\frac{100}{R}\sqrt{\frac{1}{L}\sum_{i=1}^{L}RMSE(I_m)^2}$ Where R is the mean radiance of the L spectral bands of the original MS bands	**SD:** Standard deviation is given by, $\sigma = \sqrt{\frac{1}{N}\sum_{j=1}^{N}(Y_j-\bar{Y})^2}$ Where Yj is the vector data and y is the mean value.
SSIM: Structural similarity index is given as, $SSIM\ (x,y) = \frac{(2\bar{X}\bar{Y}+C1)(2X\sigma_{xy}+c2)}{(\sigma_x^2+\sigma_y^2+C_2)X((\bar{X})^2(\bar{Y}^2)+C1)}$ Where $\bar{X}$ is the average of x and $\bar{Y}$ is the average of x	**BIAS:** Bias of an estimator is given as, Bias=E (H)-θ

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Figure 3: *(a) Input image, (b) RGB to HSV, (c) Histogram equalization,(d) Adaptive histogram, (e) Histogram matching, (f) Unsharp masking.*

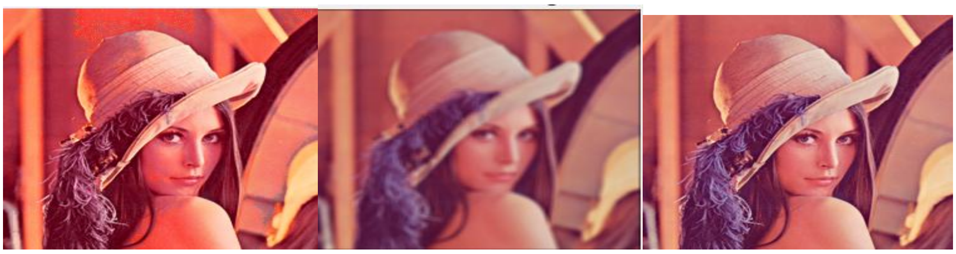


Figure 4: *(a) Homomorphic filter, (b) Bilateral filter, (c) Trilateral filter.*

Fig. 4 shows different filtered images. Performance analysis of various filtering methods is done and measured in terms of different image quality parameters as tabulated in Table 1.

Table 2: *Comparison results of spatial and frequency images on the basis of image quality measures.*

	SSIM	MSE	PSNR	RASE	CC	SD	ENTROPY	ERGAS	RMSE	BIAS
Histogram Equalization	0.8780	0.4485	51.6129	5.3344	-0.370	999.9641	5.4194	1.06689	0.1863	0.9972
Adaptive Histogram	0.9364	0.5049	51.0985	5.3176	0.9427	999.9771	13.8564	1.06352	0.1860	0.9960
Histogram matching	0.8739	0.1421	56.6058	5.3397	0.7365	999.9958	11.5119	1.06794	0.1864	0.9980
Unsharp masking	0.9648	0.4400	51.6962	5.3192	0.9949	999.9863	14.5924	1.06384	0.1860	0.9961
Homomorphic filter	0.9631	0.4664	51.4431	5.3148	0.9740	999.9792	13.3228	1.06296	0.1859	0.9957
Bilateral filter	0.9941	0.4295	51.8008	5.3223	0.9530	999.9878	14.5895	1.06446	0.1860	0.9964
Trilateral filter	0.9954	0.4175	51.9451	5.3343	0.9830	999.9918	15.1995	1.06414	0.1900	0.9985

From the Table, the PSNR and Entropy values for different methods are around 56dB and 14.59, respectively. Histogram matching and unsharp masking enhancement of the spatial image give good result as compare to other techniques applied to it. Both the techniques showed similar values for all the quality parameters. From the entropy results, the decreased entropy indicates the loss in the information content through the Histogram Equalization (5.4194) method. However, higher value of entropy using unsharp masking (14.5924) method indicates that there are increases in information, and the spatial performance is improved. Calculate the correlation coefficient between each spatial image and original image was calculated to see how each domain algorithm affects the compliance with the original images. Unsharp masking and adaptive histogram techniques were the most successful in this regard with the values of correlation coefficient of 0.9949 and 0.9427, respectively. ERGAS applies the root mean square error (RMSE) to compare original image and reference images; hence, it is a difference-based measure. It has lower values for better quality; good quality is achieved when the index is less than 3. Amongst all the spatial methods, only adaptive histogram method has value for ERGAS less than 3, which is 1.06352.

After computation of quality parameters of spatial techniques, results depicted that for frequency domain has PSNR and entropy value is maximum for trilateral filter which is around 51dB and 15 respectively. ERGAS value is better for Homomorphic filter i.e. 1.06296 and correlation coefficient value is well for Trilateral filter i.e., 0.9830.

Image quality assessment of digital transform domain images

The proposed algorithm is tested for host image such as “lena.png” and it is perceived that there are no visual degradations on the respected watermarked images. For all the different host test images, the watermark is effectively extracted using transform domains which is shown in Fig. 5.

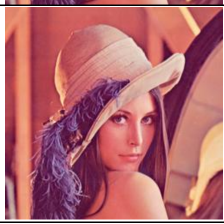
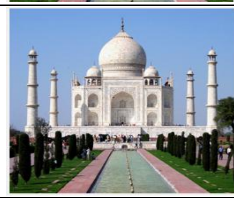
Methods	Host image	Watermark image	Watermarked image	Extracted watermark
SVD-DWT				
SVD-SLANT				
QR-DWT				
QR-HADAMARD				

Figure 5: *Transform domain images.*

After the series of experiments performed on images in MATLAB, metric values are analysed to determine the quality of watermarked image.

Table 3: *Comparison results of watermark transform images on the basis of image quality measures.*

WAVELET TRANSFORM	SSIM	MSE	PSNR	RASE	CC	SD	ENTROPY	ERGAS	RMSE	BIAS
SVD-DWT	0.9627	0.2547	54.0705	5.9993	-0.370	999.9641	3.4894	7.7336	0.1863	0.4972
SVD-SLANT	0.9626	0.0407	62.0355	1.8224	0.9988	999.4771	1.8564	1.06352	0.1860	0.7960
QR-DWT	0.9359	0.0405	60.0521	5.2095	0.9955	999.6958	3.9119	0.4189	0.1864	0.9480
QR-HADAMARD	0.9625	0.0628	62.1536	3.7780	0.9981	999.2363	2.5954	9.5560	0.1860	0.9991

From the Table 2, results show that the SVD based SLANT and QR based HADAMARD transform achieves better results compared with SVD and QR based DWT. A high value of PSNR indicates higher efficiency of the proposed algorithm.

CONCLUSION

This study was compared with spatial methods for the image processing image. After applying these techniques, it is clear that all the images have higher quality than the other methods. Only small differences are detected in the sharpness of the colors. Different image quality parameters were calculated for different spatial images. The values in Table 1indicate that the histogram matching method imparts better improvement amongst other methods. In addition, it is a useful technique for increasing contract in image. The Adaptive Histogram method gave the poorest results. Further, enhanced image was subjected to three different filtering techniques. Similar image quality parameters were applied to the filtered image. The values in Table 2indicate that the trilateral filter method imparts better image enhancement compared to other methods which is the advanced filtering method. This studydeals the simulation and analysis of digital image watermarking using discrete wavelet transform .The performance metrics showed that SVD based slant and QR based HADAMARD technique is useful in insertion of watermark in such a way such that intruder cannot trace it easily and there is less quality of loss after the insertion of watermark inside the images.

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